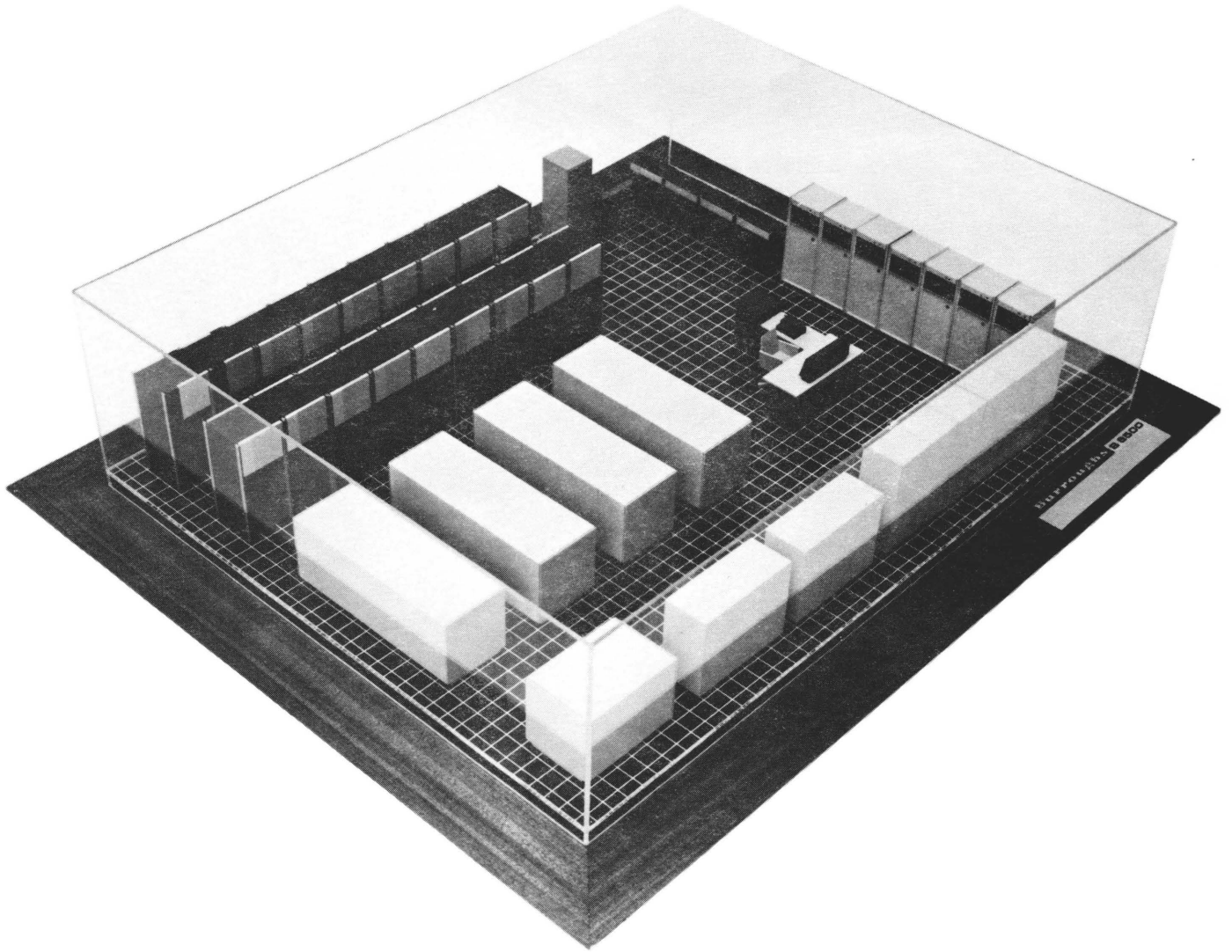


B8500

INFORMATION PROCESSING SYSTEM



Burroughs Corporation



Organization of the B8500 system is such that computer, memory, and input/output modules are physically and functionally separated. Interconnection is accomplished by means of a central exchange, with all computer and input/output modules having equal and simultaneous access to the memory modules of the system.

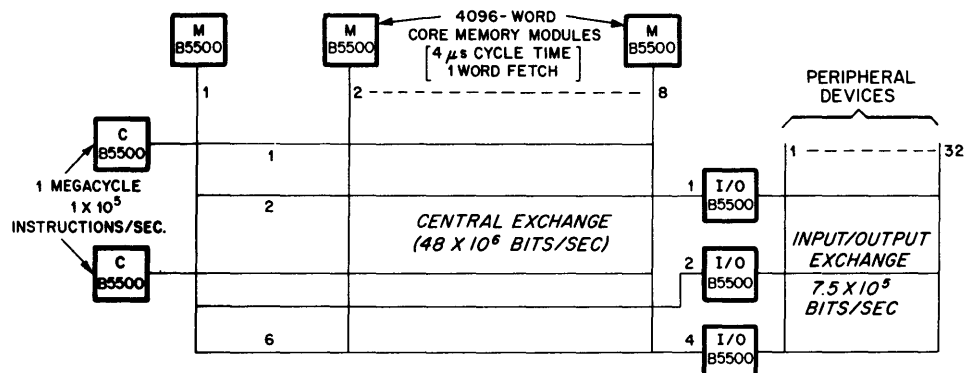
INTRODUCTION

The B8500 is a dynamically modular, very large scale, information-processing system in which the latest technological advances in monolithic integrated circuitry and thin-film memory achieve extremely fast and versatile computing power. The B8500 is intended for the user whose computational and communications needs are more complex and demanding than can be effectively solved by a conventional approach to electronic data processing or even by dispersed multicomputer installations.

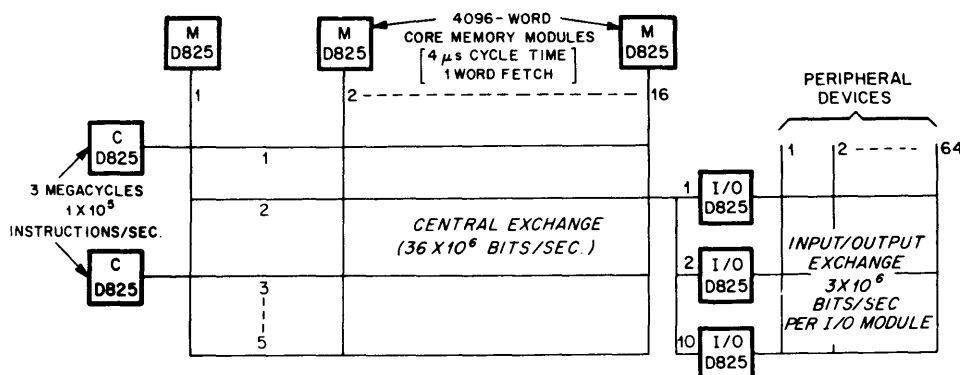
Functional and physical modularity has been the distinguishing characteristic of the Burroughs Corporation EDP line, with the B5500 commercial data-processing system and its military counterpart, the D825, being the outstanding examples. This modularity has permitted a building block approach to applications in which varying numbers of computer, memory, and input/output modules are utilized. The latest addition to the line, the B8500, exploits this modular system design to the ultimate degree.

Typical of applications for which the B8500 can be used effectively are centralized management information processing, efforts involving large time-sharing requirements, real-time communications, store-and-forward message processing, centralized or decentralized scientific and engineering calculations, and Command and Control. Inherent in a system which can accomplish these goals is the necessity for efficient multiprocessing, time sharing, and true functional modularity.

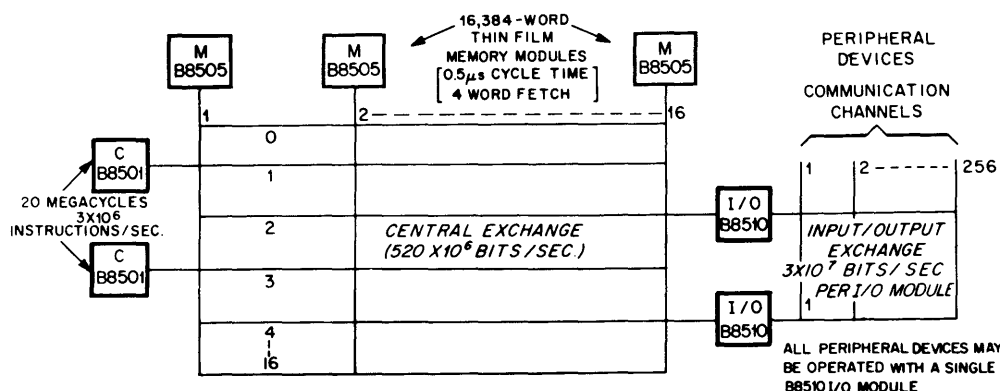
B5500 MODULAR DATA PROCESSOR



D825 MODULAR DATA PROCESSOR



B8500 MODULAR DATA PROCESSOR



The unique modular system organization, developed by Burroughs Corporation and proved in use by B5500 commercial and D825 military data processing systems, has been extended to the very large scale B8500. This organization permits multiple computer and I/O modules to fully share the memory, making effective multiprocessing practical. In the B8500, as many as 16 memory modules and a combination of up to 16 computer and/or I/O modules can be interconnected to provide a data transfer rate of 520×10^6 bits per second.

SYSTEM CHARACTERISTICS

In order to handle the requirements of large-scale information-processing systems effectively, certain system capabilities are necessary. These are:

- System flexibility for growth and modification.
- Real time response to external stimuli.
- High system reliability, with minimum module downtime.
- Dynamic responsiveness to human operators and users at dispersed locations.

These capabilities are realized in the B8500 through the interrelation of the hardware, software, and organizational concepts embodied in the following features:

- Extensive executive program.
- Modular software.
- Multiprogramming and multiprocessing for increased throughput.
- Capability for multiple, simultaneous, high-speed input and output.
- System expansion.
- High system reliability and availability.
- Extensive interrupt and external request capability.
- Efficient use of storage.

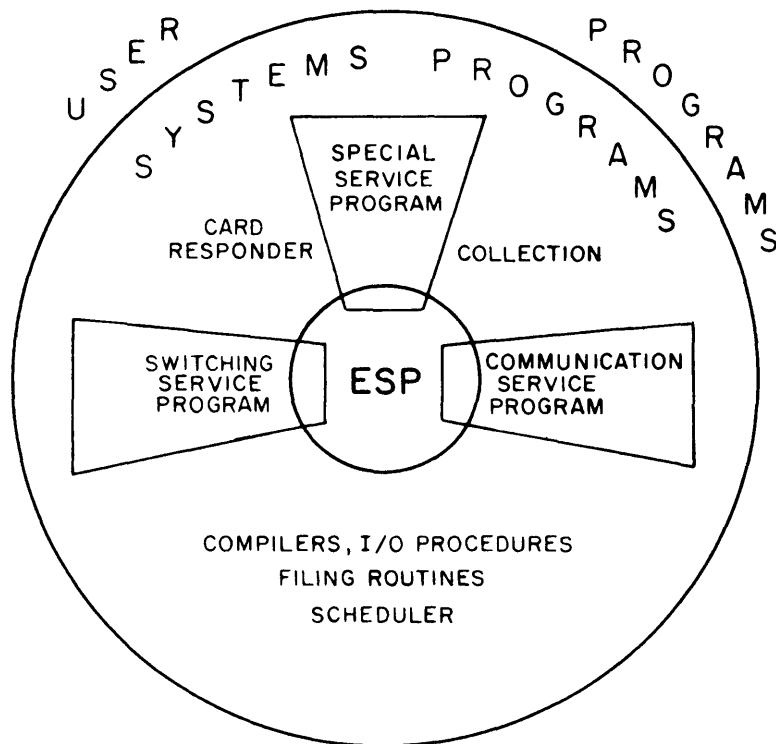
EXTENSIVE EXECUTIVE PROGRAM

The executive program supervises the compilation of all programs for generating data and program objects in a format that permits the most efficient handling by the executive program. Memory bounds and dynamic storage protection permit programs to be debugged while production programs are being executed.

The executive program is written for use with the maximum B8500 system configuration (16 memory modules and 16 processor or input/output modules). This approach permits automatic selfregulation as configurations change and provides the basis for automatic scheduling around any malfunctioning module. (The executive program is based on experience with similar executive programs developed for other modular processors. They include the Automatic Operating and Scheduling Program (AOSP) for the D825, the Automatic Message Operating System (AMOS) for the D825, and the Master Control Program (MCP) for the B5500.)

MODULAR SOFTWARE

Modular software makes it easy to add or modify functions in order to advance to new modes of controlling and processing problems. The segmentation of a job -- organizing it into a number of data and program objects which do not need to be in main memory at the same time -- permits jobs to be run with much less memory than would normally be required. This is particularly important in on-line, real-time applications where the sequence of jobs is constantly changing and where multiprogramming is essential to achieve the greatest equipment utilization.



The Executive Scheduling Program (ESP) is the heart of the B8500 operating system. Surrounding the ESP is a functionally segmented selection of service and systems programs.

MULTIPROGRAMMING AND MULTIPROCESSING FOR INCREASED THROUGHPUT

Multiprogramming in the B8500 is essential for making the most effective use of the high-speed processing capability of the system. Programs are run when all necessary information has been assembled on the high-speed disk file; however, while any given program is waiting for additional inputs from the disk file, other jobs can be activated. Waiting time is therefore not wasted time. Multiprogramming also occurs when programs are shared by more than one user program. During periods of extensive compiling, for instance, two or more compiling jobs might be programmed at the same time from a single copy of the compiler in main memory.

Multiprocessing occurs at many levels in the B8500. I/O operations occur almost completely independently of the processor module and in parallel with processor module operations. Multiprocessing occurs in multiple-processor installations, so that two processor modules almost double the throughput of the system. In addition, the unique internal organization of the system permits multiprocessing within a single processor module and gives more efficient execution of single and multiple programs. Memory processor operations can also occur independently of the other system operations. The instructions of the B8500 facilitate such operations as list searching.

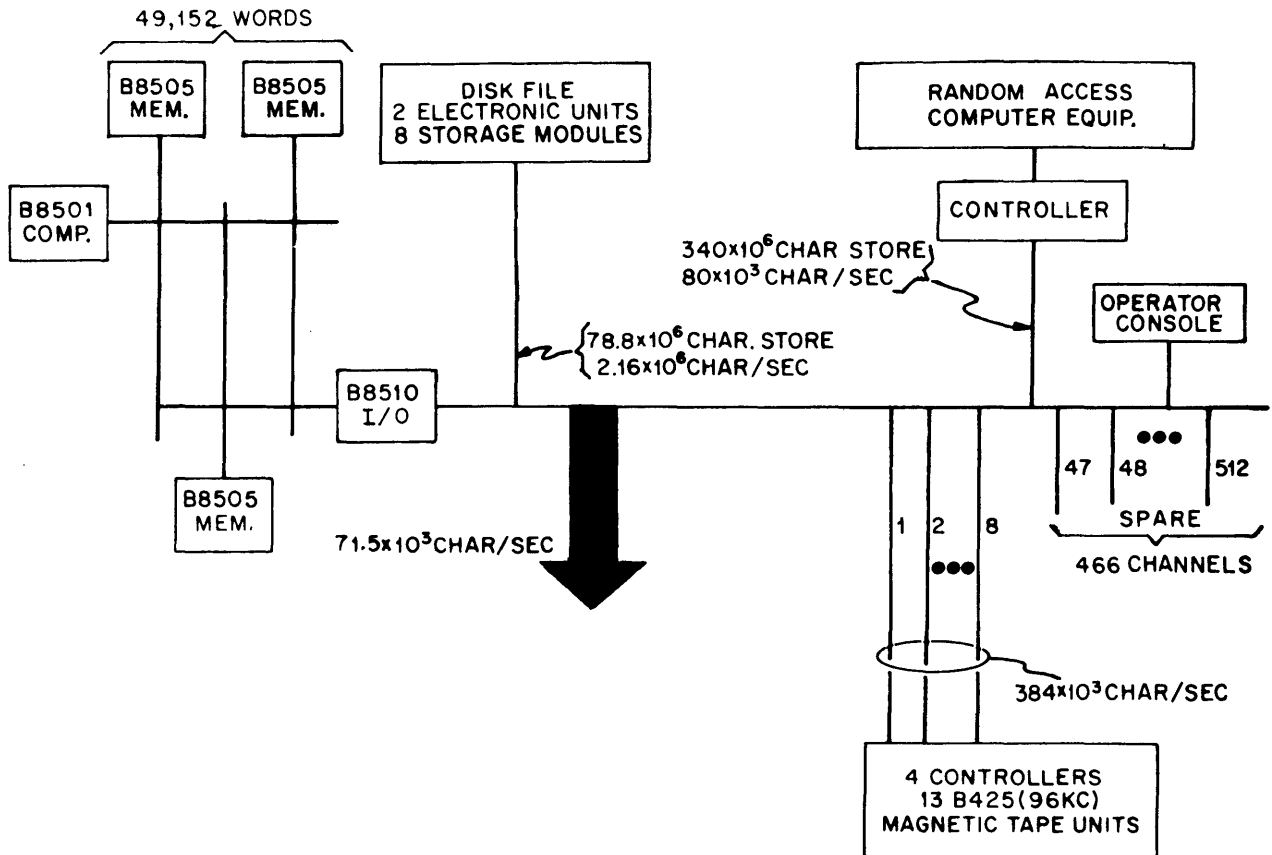
CAPABILITY FOR MULTIPLE, SIMULTANEOUS, HIGH-SPEED INPUT AND OUTPUT

Up to 512 simplex peripheral channels may be buffered and controlled by a single input/output module, which handles peripheral devices, such as card readers, magnetic tape units, "Teletype" equipment, and display devices. Additional devices can be handled if the I/O channels are multiplexed. The I/O module has an independent processing capability which minimizes the amount of computer monitoring. One of the primary functions of the I/O module is to automatically enter into high-speed disk files the low-speed data coming from external peripheral devices. The central processor thus services peripheral devices from the high-speed disk file, thereby increasing the total efficiency of the system.

SYSTEM EXPANSION

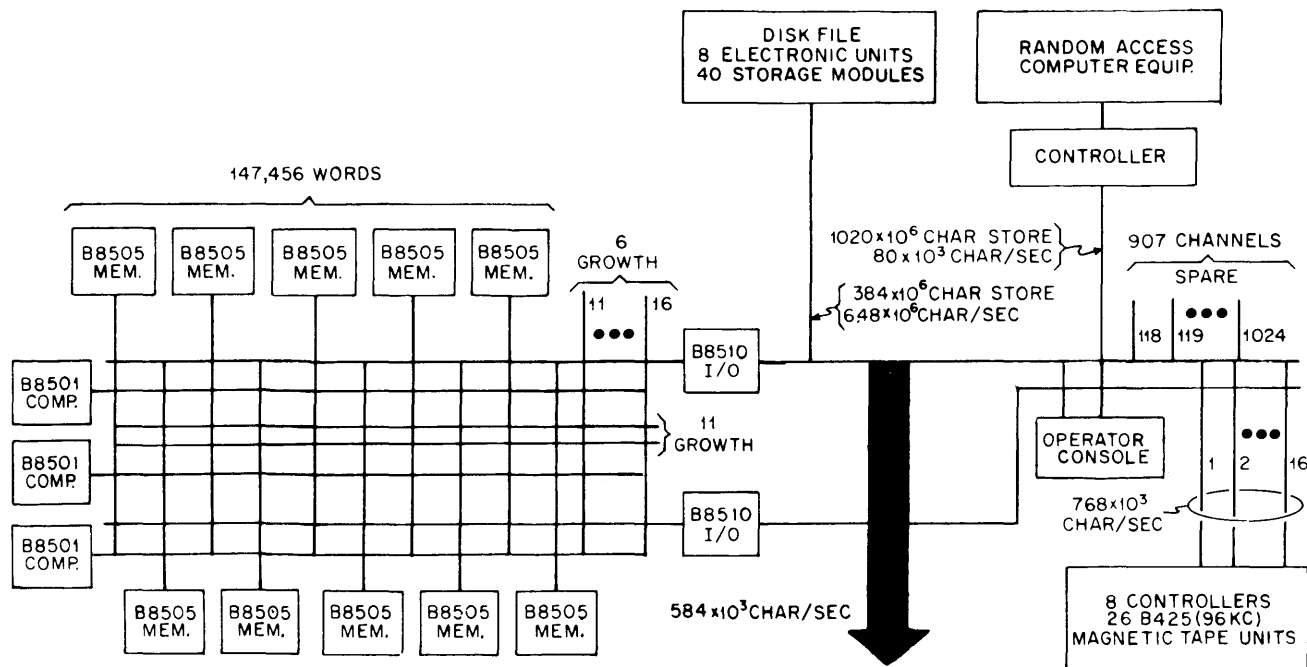
The B8500 computing system was designed for easy expansion as needed. Processor, memory, and I/O modules can be added and begin operation immediately without interruption of the system. All software is written to utilize the equipment available at a given moment in any system configuration. If more equipment is made available through expansion, greater throughput is realized.

TYPICAL B8500 SYSTEM



Typical B8500 System: A typical small B8500 system might include one computer module, three memory modules, and one input/output module to service two disk files and 13 tape units, as well as other random access equipment and a console. The data transfer rate for such a system would be approximately 71.5×10^3 characters per second. The I/O is capable of handling many more peripheral devices, as shown by the 466 spare channels.

FURTHER EXPANDED B8500 SYSTEM



Expanded B8500 System: The B8500 system might typically be expanded to include three computer modules, 10 memory modules, and two input/output modules which service eight disk files and 26 tape units, as well as other random access and console equipment. The data transfer rate for such a system would be 584×10^3 characters per second, with 907 I/O channels still available. Any combination of 11 I/O modules or computer modules and six more memory modules could still be added to achieve a maximum configuration.

HIGH SYSTEM RELIABILITY AND AVAILABILITY

Highly advanced circuit and memory techniques, in conjunction with the unique interconnection network in the B8500 computing system, provide extremely high availability and reliability. The interconnection network permits the various functional modules to simultaneously communicate without restriction. This network is distributed among the units it services and exists as part of the functional module. The system, therefore, adjusts to any change in its configuration. Thus, if there are at least two modules of the same type in the system, the system will remain operative even though one module is not available. Throughput will continue, but at a proportionally reduced rate.

EXTENSIVE INTERRUPT AND EXTERNAL REQUEST CAPABILITY

The B8500 has a comprehensive interrupt system utilizing condition and mask registers to control interrupt conditions. An interrupt processor program determines what action is to be taken for each of the interrupt conditions.

External requests for service are specially encoded for fast recognition by the I/O module. I/O service programs communicate directly with peripheral equipment and begin the necessary response to the request. If the request requires processing in the computer module, an interrupt is passed on to the processor for the proper scheduling of the request for service.

EFFICIENT USE OF STORAGE

The B8500 system utilizes a hierarchy of memories ranging from the 0.1-microsecond cycle thin-film memory in the computer modules, through the high-speed disk file system, to tape storage. Throughput is maintained at a high level by balancing the flow of information among these various memories. The B8500 executive program manages this information flow so that data is available in high-speed (0.5 microsecond) main memory storage when required by the operational program.

Look-ahead logic transfers data and instructions from the 0.5-microsecond memory to the 0.1-microsecond memory for execution. The 0.5-microsecond main memory communicates with the next level in the hierarchy, namely the fast disk file system, which has an average transfer time of 5 microseconds per word. In general, the executive routine collects programs and data in the disk file before initiating their execution. As much data as is needed at any one time is then brought into the 0.5-microsecond main memory by the executive program.

B8500 HARDWARE CHARACTERISTICS

The flexibility inherent in the modular organization of the B8500 enables Burroughs to offer a system tailored to meet specific computational requirements. The growth potential of a basic B8500 offers an increase in productivity by a factor of at least 10. This balanced growth is accomplished with no changes in existing programs or operating procedures. The economical expansion achieved provides greater throughput and lower cost per unit of computation.

Advanced system and hardware techniques are implemented in the B8500.

- The unique concept of modular system design provides an inherent ability to extend the useful life of the equipment due to the flexibility of application through reconfiguration of the system by modules. An accompanying advantage of the modularity feature is the modest cost of modifying system modules to incorporate proven technological developments as the need arises.
- The B8500 is fabricated with integrated circuits. The circuits themselves are integrated versions of the discrete circuit which has been the Burroughs standard in the past. The integrated version of the circuit retains high-speed characteristics plus the inherent greater reliability of an interconnected monolithic array. The system maintenance and reliability are greatly enhanced.
- Thin-film memory is used in the main storage module for the computer. The thin-film memories have been field-proven since their introduction by Burroughs and have the unique advantage of extremely high-speed performance combined with high reliability.

B8501 COMPUTER MODULE

The B8501 computer module is the latest and most powerful of the Burroughs family of modular systems. It represents the most recent state-of-the-art techniques in system, circuit, and memory design.

The computer module, in employing multiprocessing and look-ahead techniques to greatly increase processing speeds, remains consistent with the fundamental design principles of previous Burroughs computers. For example, the computer has retained:

- An arithmetic stack for automatic call-up of operands.
- A variable syllable instruction format and a 48-bit operand.
- Independent computer, I/O, and memory modules.
- A local scratch-pad memory.

To traditional and proven procedures of program execution, the concept of multiprocessing has been judiciously applied, effectively eliminating many time-consuming procedures, such as data and instruction fetches, stores, and address modifications. Paramount among the new features of the B8500 are the following:

- Instruction look-ahead: A fast-access (35 nanoseconds) buffer area in local memory.
- Associative indexing: A feature which permits any memory word to be used as an index word rapidly and automatically.
- Stack extension: A feature which permits the arithmetic stack to be pushed down in local memory to a depth of 16 words without recourse to the main memory storage.
- 20-megacycle clock: A feature which permits fuller utilization of high-speed circuitry.

B8510 INPUT/OUTPUT MODULE

The input/output module provides the necessary interface control and buffering between the peripheral equipments and the memory and computer modules. Up to 512 simplex peripheral channels may be buffered and controlled by a single I/O module. The functions of the I/O module include:

- Independent and interlacing channel operations.
- Storing in or fetching from the main memory.
- Accumulating a word in a variety of byte sizes.
- Testing for word count and character coding.
- Modifying the main memory address field.
- Sequencing descriptors for extended I/O operations.

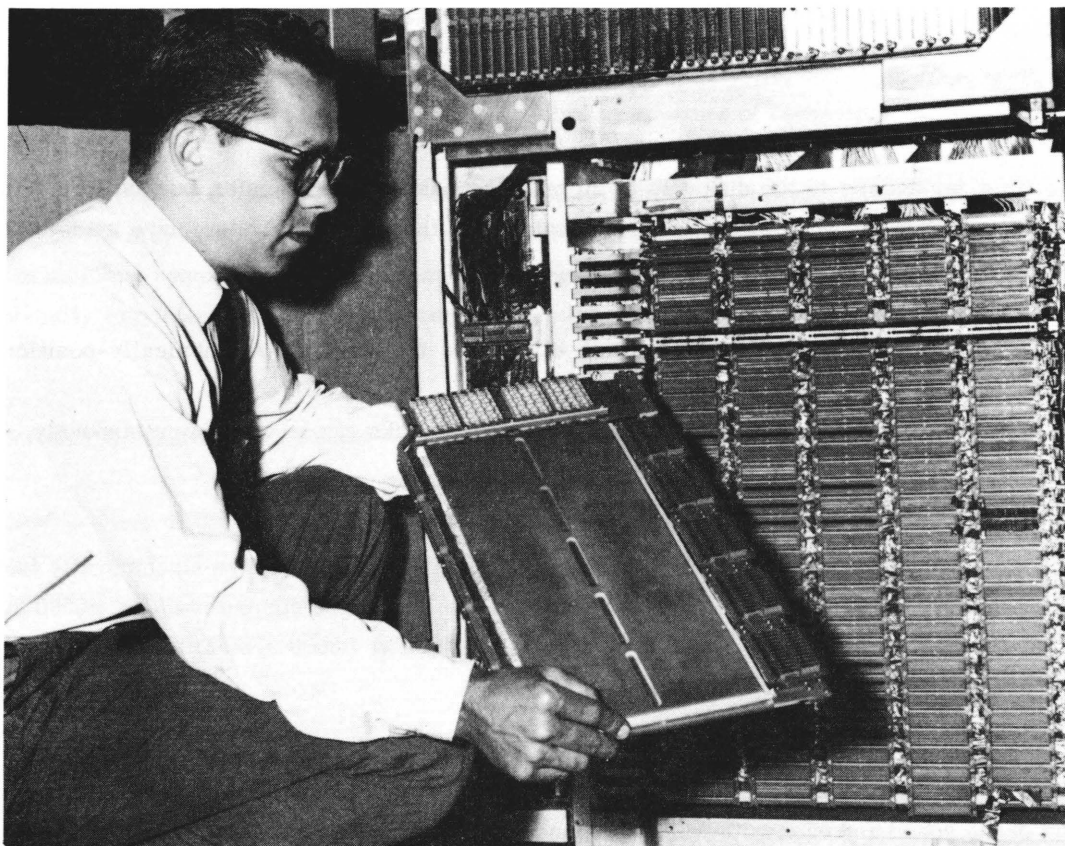
The combination of descriptor-word flexibility and a rapid channel-servicing cycle has made the I/O an outstanding element of the B8500 system.

It is important for the descriptors to control the flow of data into and out of the system; this control minimizes the amount of computer monitoring. In this respect, the I/O is semiautonomous. Thus, data is not slowed down for lack of I/O response, nor is the computer hampered by a continuing need to supervise every detail of each of the many I/O transactions.

B8505 MEMORY MODULE

The B8505 memory module is a 16,384-word memory (52 bits per word) with a full cycle time of 500 nanoseconds. Words can be stored or fetched in four-word groups so that the maximum data rate possible for a single memory module is 416×10^6 bits per second.

The speed of the main memory is the result of Burroughs' continuing development and progress in the field of thin-film memories. The basic thin-film stack and electronic circuits have been used in the D830 Development Computer System, a predecessor of the B8500.



A Burroughs engineer holds one of the thin-film memory planes which make up the main high-speed storage of the B8500. These plans are assembled in the stack shown to provide 16,384 52-bit words of storage for each memory module.

Every phase of the fabrication of the memory, from the film-deposition process to electronic circuit design, is performed at the Defense, Space and Special Systems Group facilities of Burroughs Corporation.

In addition to the raw speed capabilities of the memory, a selection of powerful logic operations has been provided for the memory module.

The B8500 system permits expansion to as many as 16 memory modules for a total of 262,144 words; each module is randomly and directly addressable.

B8500 DISK FILE SYSTEM

The average time for access to the disk file is 20 milliseconds and the transfer rate is 10.4 million bits per second. The following two important design features of the disk file system have made such speeds possible.

- A head-per-track organization which eliminates the need for mechanically-positioned head assemblies.
- A paralleled read/write operation in which eight tracks can be used simultaneously.

The disk file storage modules that are utilized in the B8500 disk file system are mechanically identical to the highly successful commercial disk storage unit used in the Burroughs computer of the B5500 and B200/B300 series. Up to 50 storage modules may be included with each B8500 system for a total of 60 million 52-bit words of storage.

The disk file is very important in meeting economically the total system requirements. The value of the disk file lies in the speed and ease with which data and programs may be made available to the main memory. Without the disk file system, the main memory would have to be prohibitively large.

B8500 SOFTWARE CHARACTERISTICS

The B8500 operating system consists of an Executive Scheduling Program (ESP), service programs (such as I/O procedure), and compilers for ALGOL, FORTRAN, and COBOL. Modularity makes the basic software design and construction much easier, but more important is the flexibility for changing to new modes of controlling and processing computing requests. The dynamic and diverse environment of on-line systems prohibits the use of an operating system whose functions are inextricably interwoven in a monolithic block of code. The B8500 operating system is therefore designed so that an independent module of code and its relation to other modules of code are well defined. As a result of this design, a function can be changed easily without affecting other functions.

The total software package is composed of a collection of small segments or modules. At any given time in the execution of the program, only the active segments need to be in memory; large contiguous areas are not required. Therefore, programs can be run with varying amounts of memory.

Program segments operate independently of their location in memory; therefore during the course of a job, program segments may be executed from several different places in memory. This movement of program segments in memory requires no modification of the segments. This flexibility in the utilization of memory is especially important with on-line systems where there are many concurrent users.

EXECUTIVE SCHEDULING PROGRAMS

The principal function of the ESP is to dynamically allocate equipment modules, such as processors, memory, and I/O channels, to a constantly changing set of jobs. This achieves a high degree of utilization of the total system. Sharing equipment modules among many programs is generally called multiprogramming. The ESP goes a step further by multiprogramming a set of jobs that consist of both user requests and operating system functions.

All the operating systems, including the compilers, are written in extended ALGOL. The advantages of using ALGOL are the following: speed of writing the program, ease in making modifications, provision of good documentation, and reduced programming time. All these advantages contribute to concise source programs.

Memory protection and an extensive file system are also provided in the operating system. This filing system provides reference to files and file items by name rather than by absolute location or storage medium.

COMPILERS

The B8500 extended ALGOL compiler uses the compiling technique known as recursive descent syntactic analysis. This technique, which was proven in use with the B5500 ALGOL compiler, enables compiling to be done quickly, makes modifications easier, and produces good object code. The B8500 extended ALGOL compiler implements virtually all of ALGOL 60 and provides extensions for I/O operations, partial word operations, string manipulation, and diagnostics.

The B8500 FORTRAN IV compiler implements the A. S. A. FORTRAN IV language. The compiling is done in one pass during which conventional precedence scan techniques are used. The hardware stack in the B8500 makes this type of analysis very fast. Library programs written in EXTENDED ALGOL can be called in FORTRAN making it unnecessary to include any assemble language coding.

The B8500 COBOL compiler implements D. O. D. COBOL 61, Extended. All the additional features in B5500 COBOL are also included in B8500 COBOL. In addition, data segmentation and the ability to compile program segments independently are also included. The character operations in the B8500 are well suited for working with character fields as required in COBOL.

SUMMARY

The B8500 is an advanced, totally integrated, information-processing system. By virtue of the dynamic modularity feature, the system can be economically expanded to meet the present and long-term needs of the user. Full functional expandability is achieved by the addition of computer memory modules and I/O modules without the necessity for changes in programming or operating procedures. The comprehensive operating system of the B8500, in conjunction with extensive interrupt facilities, dynamic storage allocation, and storage protection, provides the flexibility which is essential to meet total information processing needs.



Burroughs Corporation

DEFENSE, SPACE AND SPECIAL SYSTEMS GROUP

Paoli, Pennsylvania 19301